Attorney's Docket No.: 3771P001D

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re of Application of:

Daniel E. Grupp

Application No.: 09/612,607

Filing Date: July 7, 2000

For: ELECTROSTATICALLY OPERATED TUNNELING TRANSISTOR

Examiner: Wille, Douglas A.

Art Group: 2814

Commissioner of Patents
Washington, D.C. 20231

APPEAL BRIEF
IN SUPPORT OF APPELLANTS' APPEAL
TO THE BOARD OF PATENT APPEALS AND INTERFERENCES

Sir:

This Brief is submitted in triplicate in support of this appeal from a final decision of the Examiner, mailed December 6, 2001. Consideration of this appeal by the Board of Patent Appeals and Interferences for allowance of the above-captioned patent application is respectfully requested.

FIRST CLASS CERTIFICATE OF MAILING (37 C.F.R. § 1.8(a))

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Date of Deposit

Sarah M. Montgomery

Name of Person Mailing Correspondence

Signature

4/15/02

Date

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I. REAL PARTY IN INTEREST

The real party in interest is Acorn Technologies, Inc., a corporation of Delaware having a place of business at 881 Alma Real Drive, Suite 305, Pacific Palisades, CA 90272.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

III. STATUS OF CLAIMS

Claims 23 – 25 are currently pending, have been finally rejected and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

There are no currently pending amendments.

V. SUMMARY

A. Summary of the Invention

The present invention concerns a transistor-like device in which a conduction path from a source to a drain (or vice versa) passes through a pair of tunnel junctions. The tunnel junctions are separated by an island of, for example, semiconductor material (or another material having a non-uniform density of energy states) and each has a resistance less than or equal to approximately a quantum resistance. The conduction path is formed by shifting energy states of the island. In this context, the phrase "non-uniform density of energy states" means at least one region that contains available energy states adjacent to at least one region that does not contain any available energy states. Specification at page 6, lines 1-17; page 9, line 17 – page 10, line 3. To understand the importance of the present invention (which provides a device that is capable

of operating at room temperatures, unlike Coulomb blockade devices which operate at or near very low temperatures), some background is helpful.

In seeking to address problem that have been encountered when trying to construct MOSFET devices with channel lengths less than 0.1 microns, researchers have been investigating transistor devices based on the quantum behavior of electrons. A number of very small scale devices that exploit electron tunneling are known in the art and some are discussed in detail in the Specification at pages 2 - 5. Among the better known of such devices are resonant tunneling transistors (RETs) and single electron transistors (SETs). An important concern in the design of a single electron transistor is the resistance of the tunnel junctions. It is best for a single electron transistor to have tunnel junctions with relatively high resistances (i.e., much greater than a quantum resistance $R_q = h/2e^2 \approx 26$ KOhms, where h is Planck's constant). If the resistance of the tunnel junctions is too low, then the number of electrons on the island is not well defined. Operation of a single electron transistor requires that the tunnel junctions have sufficiently high resistances such that electron locations are well defined as being either in the island or outside the island. However, high tunnel junction resistance results in a high resistance between source and drain contacts, even in a fully 'ON' state. A high resistance limits the switching speed and increases the power consumption of the device. Therefore, single electron transistors are limited in their electrical characteristics and potential applications. Specification at page 4, line 20 – page 5, line 4.

Unlike single electron transistors, however, an electronic device configured in accordance with the present invention employs low-resistance tunnel junctions. More specifically, the present invention provides a transistor-like device having a pair of tunnel junctions, each with a resistance less than or equal to approximately the quantum resistance ($R_q \approx h / 2e^2$), and being separated by an island formed of a material having a non-uniform density of energy states. In essence, by eschewing the Coulomb blockade approach (as is used in single electron transistors), the present circuit is able to operate at room temperatures without the severe size restrictions imposed on Coulomb blockade devices. Furthermore, the present circuit differs from resonant tunneling transistors (RTTs) and similar devices, which rely on quantum wells to set the energy scale of the device for its operation. Specification at page 9, lines 2 – 11.

One method of operating an n-type transistor-like device configured in accordance with the present invention is explained at page 15, lines 6 – 17 of the Specification, with reference to Figure 6. In summary, if a

small bias voltage is applied between a source and a drain of the device and no gate voltage is applied (i.e., the gate and drain are held at the same voltage) current will not tunnel between the source and the drain because the bottom edge of the island's conduction band is higher in energy than the source Fermi energy. However, when a positive voltage is applied to the gate with respect to the drain, the conduction band is lowered in energy so that it aligns with the source and drain Fermi energies. Therefore, when a small negative voltage is applied to the source with respect to the drain, electrons can tunnel from the source, through one of the tunnel barriers to the island, and through the second tunnel barrier to the drain. Alternatively, a negative voltage applied to the drain will cause electrons to tunnel in the opposite direction. Therefore, a sufficiently positive bias voltage applied to the gate (with respect to the drain) allows the device to conduct current in both directions.

Claim 23 is presented below with elements read on Figure 5 of the drawings as required in MPEP 1206.

> A method, comprising forming a conduction path between a pair of tunnel junctions (34, 36) each having a resistance less than or equal to approximately a quantum resistance by shifting energy states of an island (26) formed of a material having a non-uniform density of such energy states, the island being disposed between the tunnel junctions.

As stated in MPEP 1206, the claims are not to be limited to this embodiment by such reading.

B. Summary of Rejections

Claims 23 - 25 were rejected under 35 U.S.C. 112, second paragraph, because the Examiner indicated that the phrase "having a non-uniform density of energy states" was not understood. [Final Office Action of December 6, 2001, p. 2.]

Claims 23 - 25 were also rejected under 35 U.S.C. 102(b) as being anticipated by Serge Luryi and Frederico Capasso, "Resonant Tunneling of Two-Dimensional Electrons Through a Quantum Wire: A Negative Transconductance Device", Appl. Phys. Lett. 47 (12), pp. 1347 - 1349 (December 15, 1985) ("Luryi"). [Final Office Action of December 6, 2001, p. 2.]

C. Summary of the Reference

Luryi describes a quantum well device that relies on resonant tunneling of electrons in a so-called quantum

wire. Luryi at p. 1347. The device operation is illustrated in Figure 2 (page 1348), wherein it is shown that application of a drain bias causes energies of certain electrons in a source to match unoccupied levels of the lowest 1-D subband (E_0') in the quantum wire, thus allowing current to flow. The source and drain are actually electron gasses, which are created by applying a positive gate voltage. Luryi at p. 1347. This gate voltage can be used to adjust the energy level E_0' and control the tunneling current. Luryi at p. 1349

VI. ISSUES

1. Whether claims 23 - 25 are patentable despite the use of the phrase "having a non-uniform density of energy states"?

2. Whether claims 23 - 25 are patentable over Luryi?

VII. GROUPING OF CLAIMS

For the purposes of this appeal, claims 23 - 25 stand or fall together.

VIII. ARGUMENT

A. The Present Claims Recite Specific, Articulated Features that are Well Defined in the Specification and Therefore Meet the Requirement of Specificity Under 35 USC 112, Second Paragraph

The rejections raised by the examiner in the Final Office Action reflect a basic and fundamental misunderstanding of the nature of the present invention. For example, the examiner rejects the present claims as being indefinite under 35 U.S.C. 112, second paragraph, because the island structure described in the claims is indicated as having "a non-uniform density of such energy states". It appears the examiner does not understand this phrase.

The rejection of the claims on this basis should be reversed. At the outset, it should be noted that the parent application, 09/296,858, now U.S. Patent 6,198,113, issued with claims having identical language. No objections to the use of this terminology were ever raised during prosecution of that application; therefore it appears the USPTO has taken inconsistent positions on this matter. For at least this reason, the present rejections should be removed.

Furthermore, the specification provides a clear and unambiguous description of the questioned claim terminology. For example, at page 6, lines 4 – 7, the phrase "non-uniform density of energy states" is defined as at least one region that contains available energy states adjacent to at least one region that does not contain any available energy states. Additionally, at page 9, line 17 et seq., an embodiment of a transistor configured in accordance with the present invention is described as including an island made of a material having a band gap. Importantly, at room temperature, the valence and conduction bands of the island behave as continuous energy bands. Thus, although the bands are separated, and the island may thus be described as having a non-uniform density of energy states, the bands themselves behave as continuous energy bands and not quantum states. The concept of a non-uniform density of energy states is further explored at page 13, line 16 et seq. of the Specification. For all these reasons then, the claim terminology is neither vague nor ambiguous in light of the present disclosure and the rejections of the claims under 35 U.S.C. 112, second paragraph, should be reversed.

B. The Present Claims are Patentable Over Luryi, Which Fails to Teach or Suggest a Device that <u>Operates on the Basis of Using an Island Having a Nonuniform Density of Energy States</u>

The above discussion also points out the reason why the claim rejections under 35 U.S.C. 102 in view of Luryi et al. are inappropriate. The Office Action tacitly admits that the device described by Luryi includes a quantum well. See, e.g., Office Action at page 3, paragraph 2. That is, the device described by Luryi relies upon the quantum nature of the well for its operating characteristics.

The Examiner then commits a fundamental error by first characterizing the presently claimed invention as being one which relies upon the use quantized energy levels, and then equates this with the principle of operation of the Luryi device. This is a mistake. As specifically recited in the claims, and as further explained above, the present invention relates to a device having a non-uniform density of energy states. That is, a device in which separated conduction and valiance bands behave as continuous, and not quantum, energy bands. This fundamental and important distinction between the present invention and the device described by Luryi has been overlooked (or at the very least, misunderstood) by the examination afforded to this application. The present claims make it clear that a non-uniform density of states is a specific property of the island material, not one arising from geometrical structures in the device, as in a quantum well. The band structure of the device may look similar to that of Luryi's quantum well, but the origin of this structure is entirely different. It is earnestly requested, therefore, that the present claims be found patentable over the cited reference.

IX. CONCLUSION

For the foregoing reasons, Appellant respectfully requests reversal of the Examiner's rejections as set forth in the Final Office Action and request that the Board direct allowance of claims 23 - 25. If there are any additional charges, please charge Deposit Account No. 02-2666.

Respectfully submitted,

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Date: 4/15, 2002

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APPENDIX A

(37 C.F.R. § 1.192 (c)(9))

The claims on appeal read as follows:

23. A method, comprising forming a conduction path between a pair of tunnel junctions each having a resistance less than or equal to approximately a quantum resistance by shifting energy states of an island formed of a material having a non-uniform density of such energy states, the island being disposed between the tunnel junctions.

24. The method of claim 23 wherein the energy states of the island are shifted by application or removal of a voltage through an electrode capacitively coupled to the island.

25. The method of claim 24 further comprising passing a current through the conduction path via electrodes coupled to the tunnel junctions.